
Space Weather Technical Forecast

Issued on Sunday, 19 February 2023 at 01:24 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Chance of M-flares (R1/R2) with an ongoing X-flare potential (R3). CME arrivals possible day 1 and 2 (19th and 20th), with G1/Minor Storms likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with only C-class flares observed. There are eight sunspot regions on the disc, the most notable is AR3229 Dki/Beta-Gamma which was still recovering from its X2.3 flare on the 17th, with post-flare arcade loops declining though the day. The visual appearance of the group is relatively straightforward, although an East-West alight polarity separation line, along with ongoing growth in penumbra area suggest this has the potential for further flaring. There are a total of eight sunspot regions on the visible solar disc, with AR3226 Eki/Beta-Gamma in the northwest also showing some increasing complexity, but remained inactive. AR3225 Dao/Beta in the southwest also exhibited some small growth. The other regions are generally mature and stable. The CMEs observed on the 18th are not Earth-directed.

Solar Wind / Geomagnetic Activity: Solar winds as measured by DSCOVR at L1 remained slightly elevated throughout varying between 420 and 460 km/s, with density near or slightly below average. The total IMF strength, Bt, was Weak ranging 4-6 nT. The north-south component, Bz, varied weakly between +5/-5nT. Phi angle was largely positive (away from the Sun). Geomagnetic activity was Quiet (Kp 1-2).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES-16 remained at background. High energy electron flux (greater than 2MeV) at GOES16 was Background to Moderate peaking 216 pfu. The associated 24 hour electron fluence has been below the Active (1e8 integrated pfu) threshold, reaching 4.64e6 integrated pfu at 19/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Low to Moderate activity expected, with an ongoing chance of isolated M-flares (R1/R2 Radio Blackouts), but also a lower chance of rising again to High with further X-flares. The main risk for further significant flaring is AR3229 in the northeast.

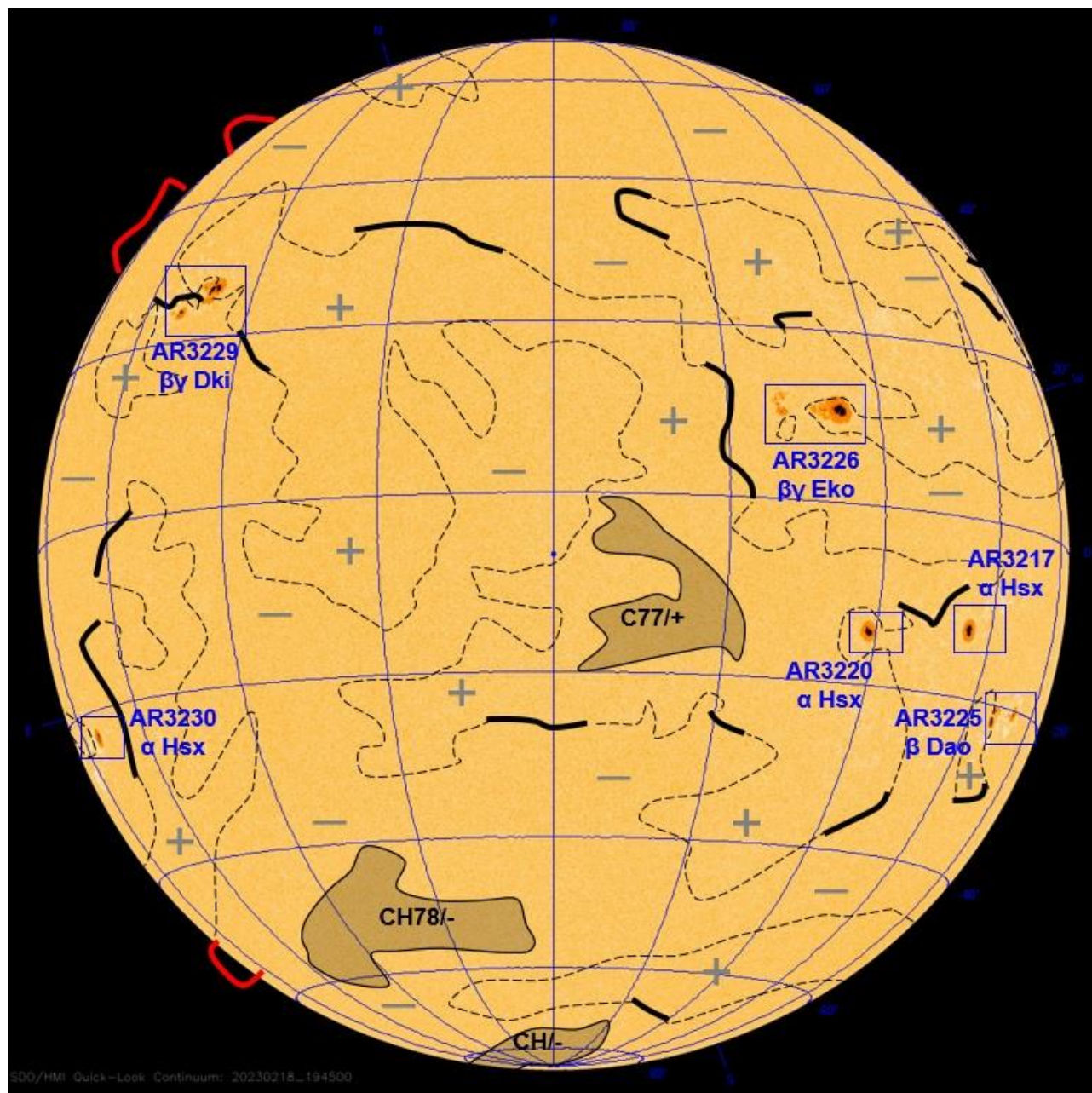
Solar Wind / Geomagnetic Activity: CMEs from the 15th and 16th have potentially missed, or been slower and consequently will be less impactful than previous forecast. These still have the potential for a late arrival, perhaps together, early on day 1 (19th). A further fast CME associated with the X2.3 flare on the 17th has been assessed to have an Earth-directed shock component, albeit with most of the material missing to the east and behind Earth. This is anticipated to arrive on day 2 (20th), however there is sufficient uncertainty that an earlier arrival on day 1 (19th) cannot be ruled out. The impact of any arrival is low confidence. Generally Quiet activity is expected with Unsettled intervals. However, CME arrivals will likely bring a period of Active, with a chance of G1/Minor Storms, perhaps reaching G2/Moderate storm with the arrival of the X-flare sourced CME.

Energetic Particles / Solar Radiation: High energy (greater than 10 MeV) proton flux is most likely to remain at background levels, but with a chance of rising towards the S1 level, perhaps

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exceeding it if any larger flares occur. High energy (greater than 2 MeV) electron flux may increase later in the forecast period, but with low confidence due to potential CME arrivals. The associated 24 hour fluence is expected to remain below the Active threshold (1e8 integrated pfu).

Figure 1. Solar Analysis Valid 19/2000 UTC.



Key: Filament ____, Prominence ____, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - γ - δ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

The geomagnetic forecast is Low confidence at this stage.

A CME from a filament eruption just east of the central solar disc was originally forecast to arrive late 17th, but has yet to be observed. There is still a small chance of a much slower CME giving a much weaker arrival early on day 1 (19th). However, the glancing influence of a CME from a filament eruption and associated C9 flare off the northwest disc (near AR3216) on the 16th could also combine with any such arrival.

More notably, a fast CME was observed on 17th with the X2 flare from AR3229. The majority of the ejecta is directed away from Earth, towards the east, however a clear halo shock was visible in coronagraph imagery. Analysis of such shocks, and their expected impact carry additional uncertainty, however this is currently expected to arrive during day 2 (20th), although some faster analyses do give an arrival as early as late day 1.

A further enhancement is also likely on later on day 3 or 4 (21st or 22nd) from the arrival of the fast wind of CH77. This is a persistent feature, although appears a little more ragged on imagery on this occasion. Furthermore, any enhancement is likely to be fairly muted due to its positive polarity being disfavoured for connection close to the March Equinox.

Geomagnetic activity is forecast to be generally Quiet with Unsettled intervals. However, CME arrivals will likely bring a period of Active, with a chance of G1/Minor Storms, perhaps reaching G2/Moderate storm with the arrival of the X-flare sourced CME. Unsettled to Active conditions also likely later day 3 or day 4 (21st or 22nd) from any CH fast wind arrival.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	40	60	20	10
Strong	G3	No	5	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
15/0815	Partial	Filament near AR3220	12E 10S	650km/s	17/1800	Late. Slower weaker impact possible
16/1250	Partial	Filament nr AR3216	45W 20N	1700km/s	Likely Missing	Glance possible early 19 th
18/0145	Full	X2.3 from AR3229	9E 4S	700 km/s	20/0900	Could arrive late 19 th Primarily shock.

Figure 2a: Enlil showing potential arrival of shock on 20th with ensemble below. Actual uncertainty wider than current ensemble, with potential for earlier arrival.

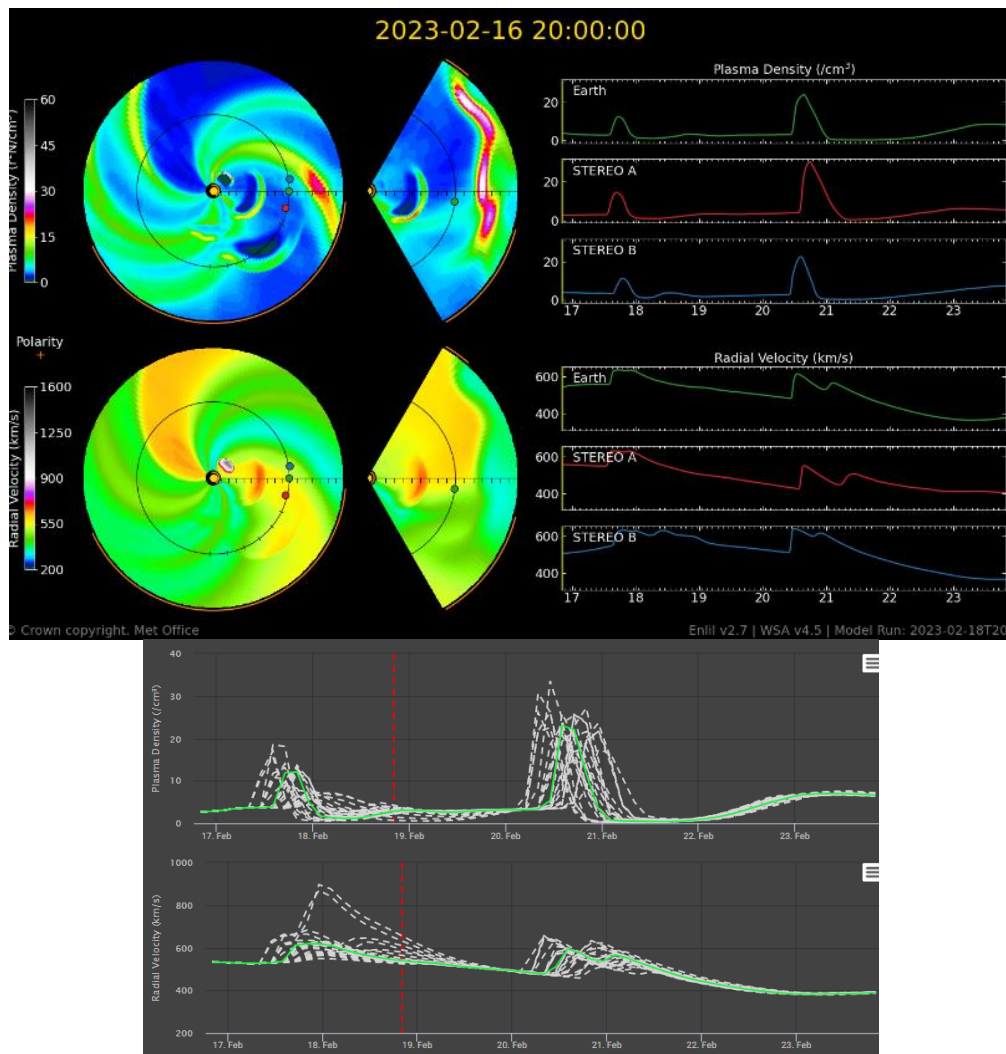
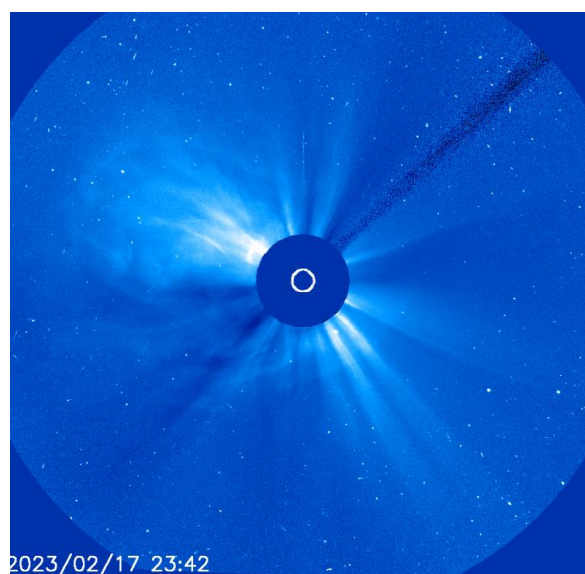


Figure 2b: SOHO Lasco C3 showing CME from X2.3 flare on 17th.



Radio Blackouts - X-Ray Flares:

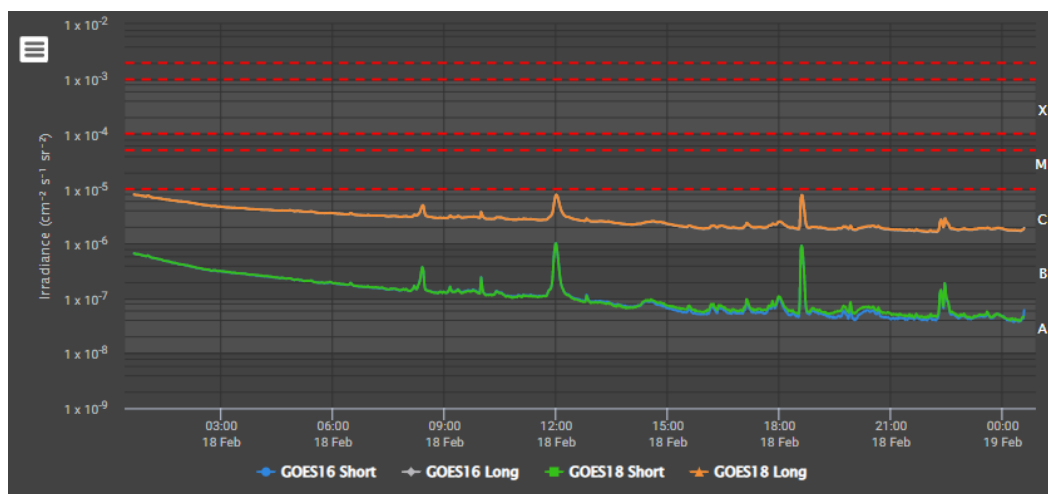
Activity is likely to persist at Low levels but with an ongoing chance of rising to Moderate. There is also a lower chance of this rising to be Strong, with any further X-flare activity.

There are eight sunspot regions on the Earth-facing disc. AR3229 Dki/Beta-Gamma in the northeast was the source of a strong X2.3 flare on the 17th, despite having a relatively simple appearance on SDO Intensitygram and Magnetogram imagery. However this belied a more complex and twisted magnetic field above the region that was visible in various SDO aia products. Post-flare, the region has remained relatively small, with only modest complexity, but still has some distinct looping visible on, for example, SDO aia-171. Some growth is also occurring in surrounding spots, suggesting an ongoing flare risk.

AR3226 Dki/Beta-Gamma in the northwest has also seen a slight increase in complexity, but has remained largely stable. The other regions are generally small, and simpler, although AR3225 Dao/Beta in the southwest has been exhibiting some slow growth.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	60	50	40	40
Very Active	R3 to R5 X Class	No	25	20	10	10

Figure 3: GOES-16/18 X-ray flux showing gradual recovery from the X2.3 on the 17th.



Solar Radiation Storms - (High Energy Protons):

High energy (greater than 10MeV) proton flux, as observed by GOES16, is currently at background levels. A proton response was not observed from the X2.2 flare on the 17th, however there remains a slight chance of further strong flares from this region. There are also a couple of spots in the western hemisphere that have the potential for M-flaring, which is a more favoured location for Earth-directed proton events. This gives an ongoing slight chance of proton count rates increase towards, or breaching the S1 Minor Radiation Storm threshold.

Radiation Storms	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq \text{S1}$	No	15	10	5	5
Very Active	$\geq \text{S3}$ *	No	1	1	1	1

* $\text{S3} \geq 10 \text{ MeV} \geq 1000 \text{ pfu}$ and / or $\geq 50 \text{ MeV} \geq 10 \text{ pfu}$. (pfu = $\text{cm}^{-2}\text{sr}^{-1}\text{s}^{-1}$)

Figure 4: SDO Intensitygram and Magnetogram of AR3229

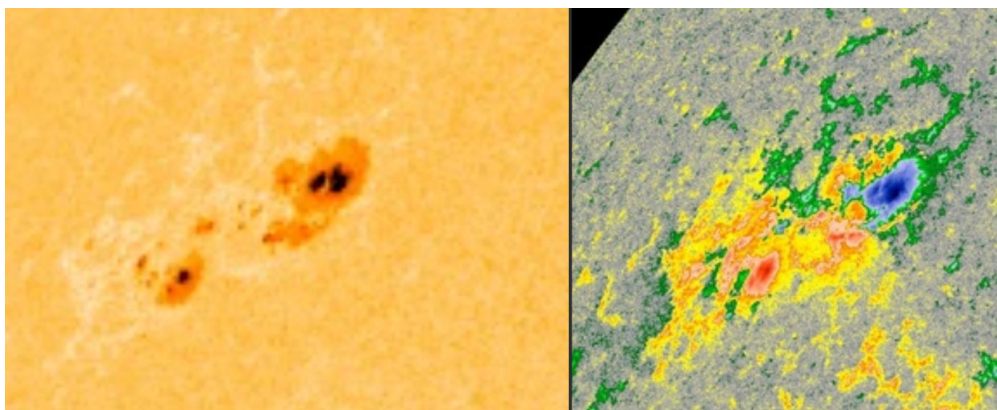
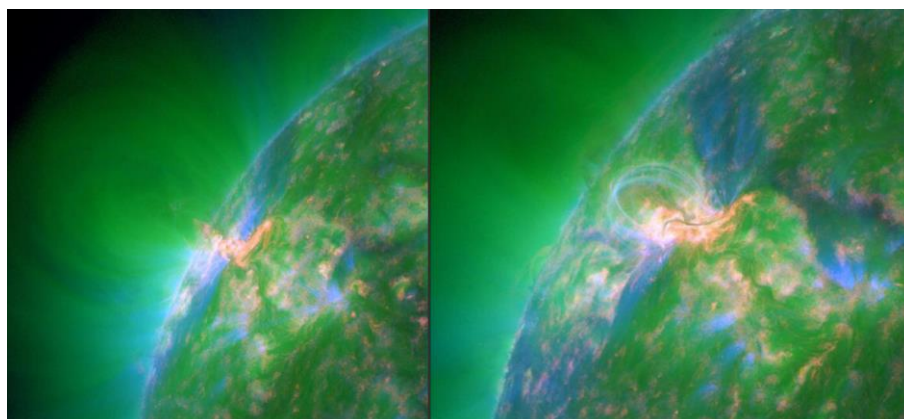


Figure 5: SDO aia-304-211-171 difference imagery showing AR3229 before the 17th X2.3 flare (left) and current conditions (right). Arcade loops visible, but also some significant looping, suggesting further notable flares possible.



High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) observed at GOES-16 is currently at Background to Moderate. Any more persistent increase in flux is likely to be suppressed by any CME arrivals through day 1 and day 2 (19th and 20th), although some recovery towards Moderate levels is then possible day 3 or day 4 (21st or 22nd). There is a slight chance this may approach high, however this is then likely to be suppressed further by any solar wind enhancement that occurs from the arrival of the high speed stream of CH77.

The associated 24 hour fluence is expected to remain below the Active threshold, with only a slight chance of rising above later in the period. REFM maintains below Active fluence, and this is likely to be a reasonable guide through the period.

GEO Electron Environment	Level ($\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^8$	No	1	1	5	5
Very Active	$\geq 2 \text{ MeV}$ $\geq 1 \times 10^9$	No	1	1	1	1

Figure 5: GOES-16 $>2\text{MeV}$ Electron Flux and associated fluence.

